(12) UK Patent Application (19) GB (11) 2 219 777 (13) A

(43) Date of A publication 20.12.1989

(21) Application No 8913423.3

(22) Date of filing 12.06.1989

(30) Priority data
(31) 8814178 (32) 15.06.1988 (33) GB

(51) INT CL⁴
B64F 1/02

(52) UK CL (Edition J)
B7G G2A3 G2BX G2B7 G2C1X G7B1 G7B3

(56) Documents cited
GB 2036668 A GB 1471583 A US 4311290 A

(58) Field of search
UK CL (Edition J) B7G
INT CL⁴ B64F 1/00 1/02

(71) Applicant
GEC-Marconi Limited

(Incorporated in the United Kingdom)

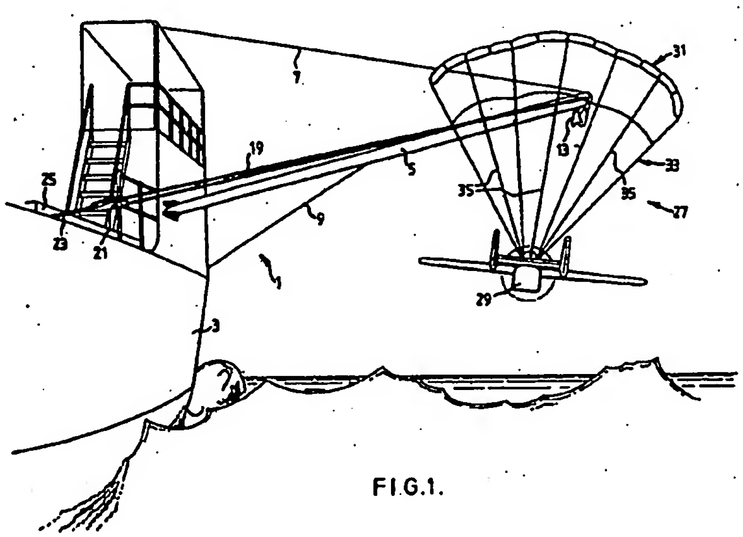
The Grove, Warren Lane, Stanmore, Middlesex, HA9 7PP, United Kingdom

(72) Inventor
Douglas Richard Taylor

(74) Agent and/or Address for Service
Pope Esq. M.B.W.
GEC Patent Department, (Wembley Office),
The General Electric Company Plc,
Hirst Research Centre, Wembley, Middlesex, HA9 7PP,
United Kingdom

(54) Flying object recovery system

(57) A flying object, e.g. an unmanned aircraft (29) recovery system comprising a recovery site arrester sub-system (1) incorporating hook means (13) and an object-borne sub-system (27) incorporating parasail lift means (31) and looped filamentary material (33) connected between the object and the parasail lift means. In operation, upon deployment of the object-borne system whilst the object is in flight, the looped filamentary material is aerially extended and supported by action of the parasail lift means, thereby facilitating engagement of the filamentary material with the hook means.



F.I.G.1.

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

GB 2 219 777 A

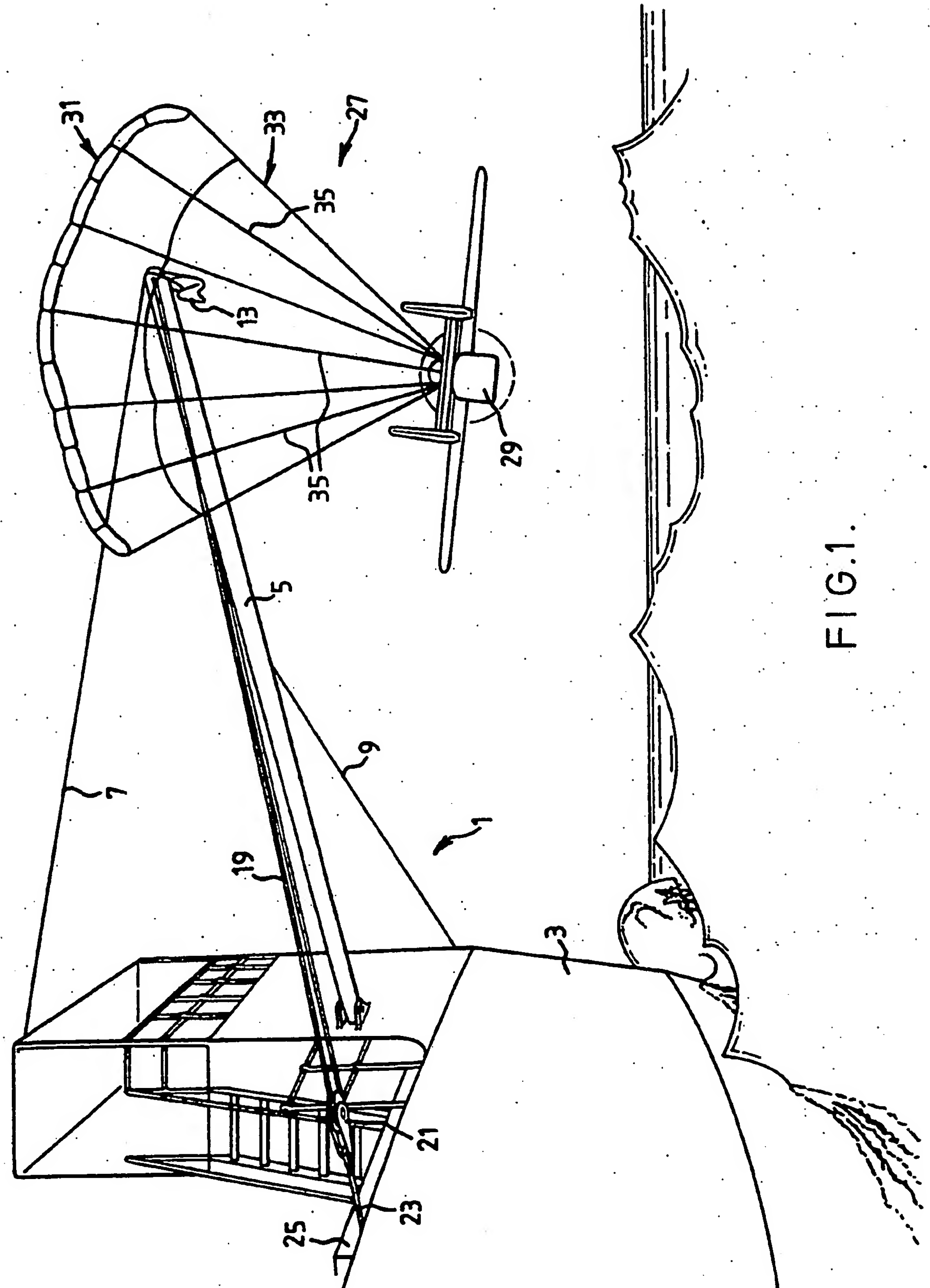


FIG.1.

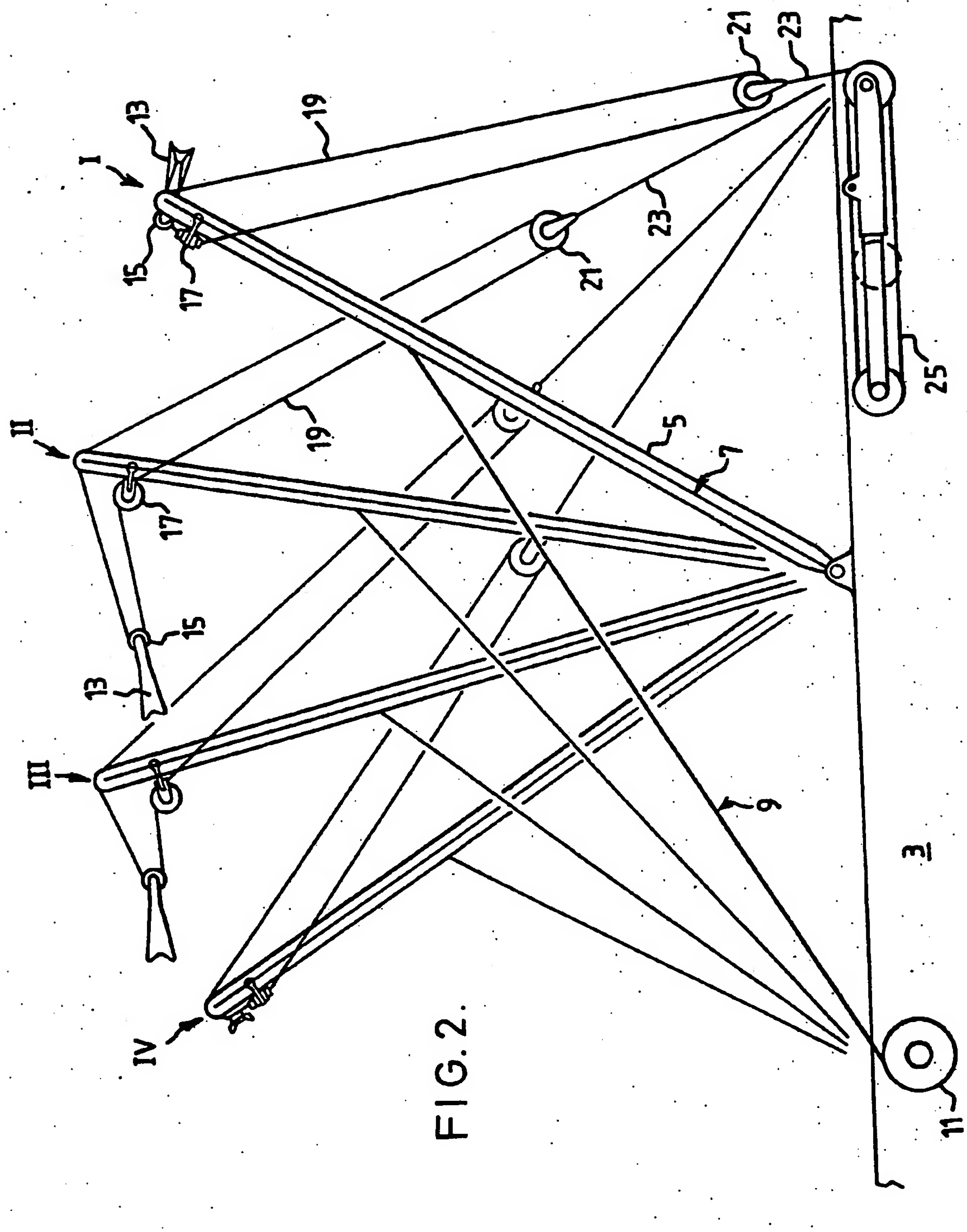


FIG.2.

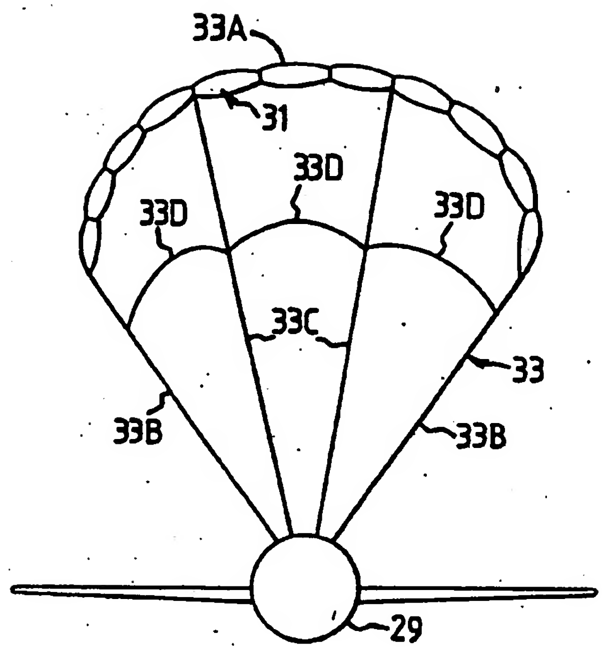


FIG.3.

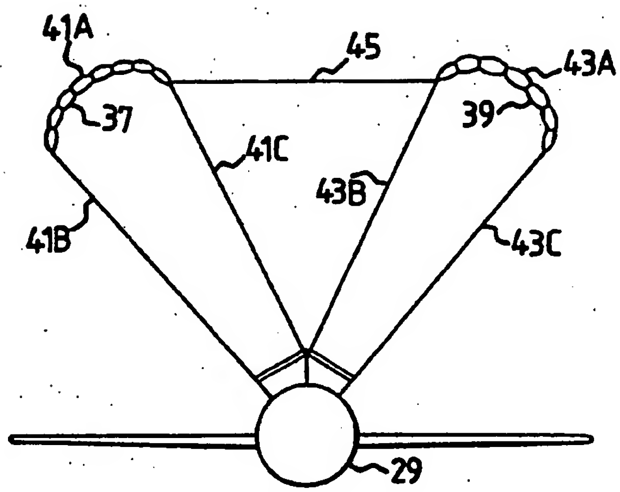


FIG.4.

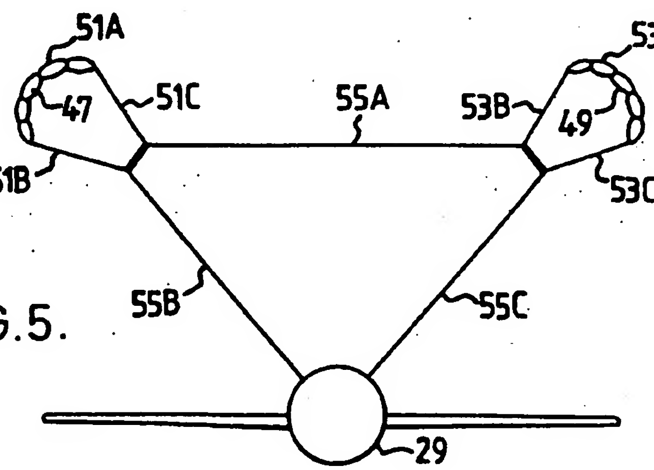


FIG.5.

2219777

FAF/3466

Flying Object Recovery Systems

This invention relates to flying object recovery systems.

More especially, although not exclusively, the invention relates to such systems suitable for the recovery of unmanned aircraft to ships.

Known methods of recovering unmanned aircraft to ships fall under one or other of four headings; controlled vertical landing; flight into a vertically disposed net; landing on an open deck; and parachute descent into the sea. Controlled vertical landing is only open to aircraft which can generate sufficient vertical thrust, e.g. helicopters. Flight into a vertically disposed net is successful only for aircraft of suitable configuration, e.g. narrow delta; for a straight winged aircraft the method has the severe disadvantage that high loadings are placed upon the wings and since first encounter is likely to be at a point forward of the centre of gravity of the aircraft, the aircraft tends to tumble in retardation, resulting in a high probability of damage to the aircraft. For a fixed wing aircraft the space requirements for landing on an open deck are prohibitive and the piloting or control problems associated with this method are considerable; also, in the case of a missed recovery the probably of damage to the ship or injury to personnel is high.

The disadvantages of the method of parachute descent into the sea include possible damage on impact, water contamination and the remaining problem of recovery to the ship.

It is an object of the present invention to provide an system for use in the recovery of a flying object whereby the above difficulties may be overcome.

According to the present invention there is provided a flying object recovery system comprising: a recovery site arrester sub-system incorporating hook means; and an object-borne sub-system incorporating parasail lift means and looped filamentary material connected between said object and the parasail lift means so that, in flight of the object, upon deployment of the object-borne sub-system, the looped filamentary material is aerially extended and supported by action of the parasail lift means so as to facilitate engagement of the filamentary material with the hook means.

In one embodiment of the invention said parasail lift means comprises a single parasail member and said filamentary material comprises a first portion incorporated into the leading edge of the parasail member so as to extend spanwise on deployment of the parasail member, and at least two riser portions each extending between the first portion and the object.

In another embodiment of the invention said parasail lift means comprises first and second parasail members, and said filamentary material comprises, for each said parasail member, a first portion incorporated into the leading edge of the parasail member so as to extend spanwise on deployment of the parasail member, and two riser portions each extending between the first portion and the object, and a third portion extending between one of the riser portions associated with one of the parasail members and one of the riser portions associated with the other parasail member.

In a further embodiment of the invention said parasail lift means comprises first and second parasail members, and said

filamentary material comprises, for each parasail member, a first portion incorporated into the leading edge of the parasail member so as to extend spanwise on deployment of the parasail member, and two riser portions each extending between the first portion and the object, a first further portion extending between the end remote from the first parasail member of one of the riser portions associated with the first parasail member and the end remote from the second parasail member of one of the riser portions associated with the second parasail member, and second and third further portions each of which extends between the object and the end remote from its associated parasail member of a respective other one of the riser portions.

In one particular system according to the invention said hook means is secured to a boom which is mounted at one end for rotation about a substantially vertical axis in a substantially horizontal plane on engagement of said filamentary material with said hook means in operation of the system, and the recovery site sub-system further includes means for retarding rotation of said boom.

In one such particular system said hook means is detachably secured to said boom and connected with said boom and said means for retarding by way of a wire so that on engagement of said filamentary material with said hook means in operation of the system, said hook means is detached from the boom thereby to cause the boom to rotate against the restraining force of the retarding means.

One recovery system is accordacne with the invention for recovering unmanned aircraft to a ship will now be described,by way of example, with reference to the accompanying drawings in which:-

Figure 1 is a general view of the system;

Figure 2 is a plan view from above of a ship-borne sub-system of the recovery system in four consecutive positions during recovery;

Figures 3, 4 and 5 illustrate various possible forms of an

aircraft-borne sub-system of the recovery system.

Referring to Figures 1 and 2, the recovery system includes a recovery site arrester sub-system 1 mounted on the ship 3. The sub-system 1 includes a swingable boom 5 pivotally mounted at one end to the side of the ship 3 for rotation about a vertical axis in a substantially horizontal plane.

The boom 5 is supported by a guy wire 7 extending upwardly from the end of the boom 5 remote from the ship 3 to a point on the ship, and a forestay 9 extending generally horizontally from the end of the boom 5 remote from the ship 3 to a point forward of the boom 3 in the direction of flight of an aircraft during recovery to a tensioner 11 for the stay 9 mounted on the ship 3.

The sub-system 1 also includes an aircraft arresting hook 13 which is detachably secured to the boom 5 at a position at the end of the boom remote from the ship by a catch (not shown) prior to a recovery operation. The hook 13 carries a sheave 15 and a second sheave 17 is hingedly secured to the boom 5 near its end remote from the ship 3. The sheaves 15 and 17 co-operate with a length of arrester wire 18 which is secured at each end to the end of the boom 5 remote from the ship 3, and between its ends passes in turn around the hook sheave 15, then the boom sheave 17 and then a third sheave 21 which is attached to one end of a retardation wire 23 the other end of which is attached to an arrester unit 25 mounted on the ship 3 which controls the speed which the retardation wire 23 is paid out.

Referring now also to Figure 3, the recovery system further includes an aircraft-borne sub-system 27 mounted on the unmanned aircraft 29 to be recovered. The sub-system 27 comprises a parasail lift means 31 and looped filamentary material 33 connected with the parasail lift means 31 and attached to the aircraft.

In operation of the recovery system on approach of the aircraft 29 to the ship 3 the sub-system 27 is deployed from the aircraft causing the filamentary material 33 to engage the hook 13

in its position at the end of the boom 5. It will be appreciated that the material 33 typically first contacts and moves along the boom 5 before engaging the hook 13.

Referring particularly to Figure 2, after the hook 13 has been engaged by the filamentary material 33 with the hook 13 and boom 5 positioned as shown at I in Figure 2, the hook 13 is first pulled off the boom 5 forwardly of the boom 5. Consequently, the arrester wire 13 is also pulled forwardly of the boom 5 with consequent movement of the sheave 21 such as to pull on the retardation wire 23 against the restraining force of the arrester unit 25. After the inertia of the boom 5 is overcome, the boom 5 rotates forwardly on its pivot, further pulling on the retardation wire 23, as shown at II and III in Figure 2. The forward motion of the aircraft 29 is consequently rapidly retarded until it eventually comes to rest with the aircraft 29 hanging beneath the boom 5 suspended from the hook 5 by the filamentary material 33, clear of the side of the ship 3, as shown at IV in Figure 2. The boom 5 is then swung inboard of the ship 3 and the aircraft 29 unhooked.

In the embodiment of the aircraft-borne sub-system 27 shown in Figures 1 and 3 the parasail lift means 31 comprises a single parasail member. The filamentary material 33 comprises a portion 33A incorporated into the leading edge of the parasail member 31 so as to extend spanwise on deployment first and second riser portions 33B formed as a unitary member with the portion 33A and each leading from a respective end of the spanwise extending portion 33A and attached at its end remote from the spanwise extending portion 33A to the aircraft 29, two further riser portions 33C extending from the aircraft 29 to intermediate points along the spanwise extending portion 33A and cross portions 33D extending between the riser portions 33B, C. The further riser portions 33C and cross portions 33D may be omitted, if desired.

Further risers 35 of filamentary material extending between the aircraft 29 and the rear edge of the parasail 31 are

also provided, but these may be of a less strong material than the material 33, since they play no part in the recovery action.

In a second embodiment of the sub-system 27, shown in Figure 4, the parasail lift means comprises two parasail members 37 and 39 and the filamentary material comprises, for each of the parasail member 37and 39, a spanwise extending portion 41A or 43A incorporated into the leading edge of the associated parasail member 37 or 39, two riser portions 41B and 41C or 43B and 43C formed as a unitary member with their associated spanwise extending portion 41A or 43A and each leading from a respective end of its associated spanwise extending portion 41A or 43A, and attached at its end remote from the associated spanwise extending portion 41A or 43A to the aircraft 29. In addition, a cross portion 45 is connected between the inner two riser portions 41C and 43B at their ends adjacent the parasail members 37, 39.

In a third embodiment of the sub-system 27 shown in Figure 5 the parasail lift means comprises two parasail members 47 and 49 and the filamentary material comprises, for each of the parasail members 47 and 49, a spanwise extending portion 51A or 53A incorporated into the leading edge of the associated parasail member 47 or 49, and two riser portions 51B and 51C or 53B and 53C formed as a unitary member with their associated spanwise extending portion 51A or 53A and each leading from a respective end of its associated spanwise extending portion 51A or 53A and attached at its end remote from the associated spanwise extending portion to the aircraft 29. In addition the filamentary material includes three further portions 55A, 55B and 55C, one 55A of which extends between the end of the inner riser portion 51C remote from the associated spanwise extending portion 51A and the corresponding end of the inner riser portion 53B, and the other two 55B and 55C of which each extends from the end of a respective one of the two outer riser portions 51B and 53C and the aircraft 29.

The embodiments of the aircraft-borne sub-system 27 shown in Figures 4 and 5 find application where the single parasail member of the embodiment of Figure 3 results in excessive drag.

CLAIMS

1. A flying object recovery system comprising: a recovery site arrester sub-system incorporating hook means; and an object-borne sub-system incorporating parasail lift means and looped filamentary material connected between said object and the parasail lift means so that, in flight of the object, upon deployment of the object-borne sub-system, the looped filamentary material is aerially extended and supported by action of the parasail lift means so as to facilitate engagement of the filamentary material with the hook means.

2. A system according to Claim 1 wherein said parasail lift means comprises a single parasail member and said filamentary material comprises a first portion incorporated into the leading edge of the parasail member so as to extend spanwise on deployment of the parasail member, and at least two riser portions each extending between the first portion and the object.

3. A system according to Claim 2 wherein said filamentary material includes at least one further portion extending between adjacent riser portions.

4. A system according to Claim 1 wherein said parasail lift means comprises first and second parasail members, and said filamentary material comprises, for each said parasail member, a first portion incorporated into the leading edge of the parasail member so as to extend spanwise on deployment of the parasail member, and two riser portions each extending between the first portion and the object, and a third portion extending between one of the riser portions associated with one of the parasail members and one of the riser portions associated with the other parasail member.

5. A system according to Claim 4 wherein said third portion extends between the ends of said riser portions adjacent the parasail members.

6. A system according to Claim 1 wherein said parasail lift means comprises first and second parasail members, and said filamentary material comprises, for each parasail member, a first

portion incorporated into the leading edge of the parasail member so as to extend spanwise on deployment of the parasail member, and two riser portions each extending between the first portion and the object, a first further portion extending between the end remote from the first parasail member of one of the riser portions associated with the first parasail member and the end remote from the second parasail member of one of the riser portions associated with the second parasail member, and second and third further portions each of which extends between the object and the end remote from its associated parasail member of a respective other one of the riser portions.

7. A system according to any one of Claims 2 to 6 wherein, for the or each said parasail member, said first portion and said two riser portions are formed as a unitary member.

8. A system according to any one of the preceding claims wherein said hook means is secured to a boom which is mounted at one end for rotation about a substantially vertical axis in a substantially horizontal plane on engagement of said filamentary material with said hook means in operation of the system, and the recovery site sub-system further includes means for retarding rotation of said boom.

9. A system according to Claim 8 wherein said hook means is detachably secured to said boom and connected with said boom and said means for retarding by way of a wire so that on engagement of said filamentary material with said hook means in operation of the system, said hook means is detached from the boom thereby to cause the boom to rotate against the restraining force of the retarding means.

10. A flying object recovery system substantially as hereinbefore described with reference to Figures 1, 2 and 3, Figures 1, 2 and 4, or Figures 1, 2 and 5.

Published 1989 at The Patent Office, State House, 66 71 High Holborn, London WC1R 4TP. Further copies may be obtained from The Patent Office. Sales Branch, St Mary Cray, Orpington, Kent BR5 3RD. Printed by Multiplex techniques ltd, St Mary Cray, Kent, Con. 1/87